

# Improving Early Adaptation Following Long Duration Spaceflight by Enhancing Vestibular Information

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Crewmember adapted to the microgravity state may need to egress the vehicle within a few minutes for safety and operational reasons after g-transitions. The transition from one sensorimotor state to another consists of two main mechanisms: strategic and plastic-adaptive and have been demonstrated in astronauts returning after long duration space flight. Strategic modifications represent “early adaptation” -immediate and transitory changes in control that are employed to deal with short-term changes in the environment. If these modifications are prolonged then plastic-adaptive changes are evoked that modify central nervous system function, automating new behavioral responses. More importantly, this longer term adaptive recovery mechanism was significantly associated with their strategic ability to recover on the first day after return to Earth G. We are developing a method based on stochastic resonance (SR) to enhance information transfer by improving the brain’s ability to detect vestibular signals especially when combined with balance training exercises for rapid improvement in functional skill, for standing and mobility. The countermeasure to improve post-flight balance and locomotor disturbances is a stimulus delivery system that is wearable/portable providing low imperceptible levels of white noise based binaural bipolar electrical stimulation of the vestibular system (stochastic vestibular stimulation, SVS). The techniques for improving signal detection using SVS may thus provide additional information to improve such strategic abilities and thus help in significantly reducing the number of days required to recover functional performance to preflight levels after long duration space flight. We have conducted a series of studies to document the efficacy of SVS stimulation on balance/locomotion tasks on unstable surfaces and motion tracking tasks during intra-vestibular system conflicts. In an initial study, we showed that SVS improved overall balance performance while standing on an unstable surface indicating that SVS may be sufficient to provide a comprehensive countermeasure approach for improving postural stability. In a second study, we showed that SVS improved locomotor performance on a treadmill mounted on an oscillating platform indicating that SVS may also be used to maximize locomotor performance during walking in unstable environments. In a third study, SVS was evaluated during an otolith-canal conflict scenario in a variable radius centrifuge at low frequency of oscillation (0.1 Hz) on both eye movements and perceptual responses (using a joystick) to track imposed oscillations. The variable radius centrifuge provides a selective tilting sensation that is detectable only by the otolith organs providing conflicting information from the canal organs of the vestibular system (intra-vestibular conflict). Results show that SVS significantly reduced the timing difference between both the eye movement responses as well as the perceptual tracking responses with respect to the imposed tilt sensations. These results indicate that SVS can improve performance in sensory conflict scenarios like that experienced during space flight. Such a SR countermeasure will act synergistically along with the pre-and in-flight adaptability training protocols providing an integrated, multi-disciplinary countermeasure capable of fulfilling multiple requirements making it a comprehensive and cost effective countermeasure approach to enhance sensorimotor capabilities following long-duration space flight.

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